NASA Advisory Council HEOMD Committee
HEOMD Overview

Bill Gerstenmaier | April 18, 2013

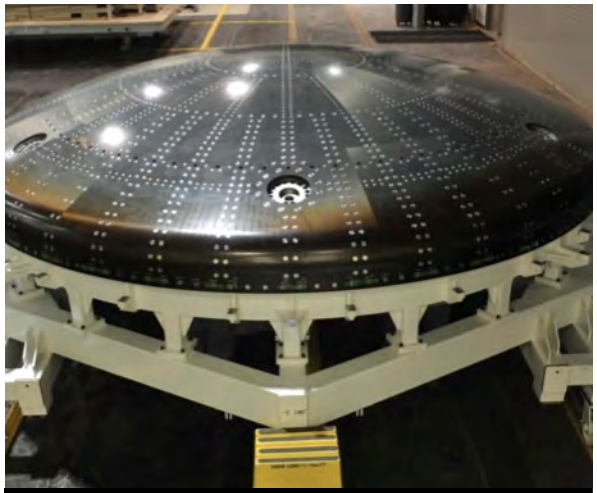
Human Exploration and Operations
FY 2014 Budget Overview

- FY 2014 Budget Submit provides $7.798 billion for HEO to lead and manage human spaceflight in and beyond low Earth orbit
- Guiding principle: focus on the mission
  - Utilize the International Space Station (ISS) to the fullest extent possible
- Develop human exploration capabilities required to explore beyond Earth orbit
- Partner with US industry to develop an American commercial crew capability to enable crew and cargo transportation to ISS
- Provide safe, reliable, access to space for NASA and NASA-sponsored payloads
- Deliver space communications and navigation services to customer missions
- Provide advanced research and technology for beyond low Earth orbit mission capabilities including an asteroid retrieval mission

Human Exploration and Operations
Program Financial Plan - FY 2014 President's Budget Request

Budget Authority ($ in Millions)	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
Human Exploration and Operations (HEO)	**7,798.4**	**7,966.9**	**7,966.9**	**7,966.9**	**7,966.9**
Exploration	**3,915.5**	**3,952.0**	**3,970.7**	**3,799.0**	**3,589.3**
Exploration Systems Development (ESD)	2,730.0	2,789.8	2,801.5	2,818.3	2,819.5
Orion Multi-Purpose Crew Vehicle (MPCV)	1,026.8	1,024.9	1,027.1	1,027.1	1,028.3
Space Launch System (SLS)	1,384.9	1,356.5	1,360.2	1,354.4	1,345.4
Exploration Ground Systems (EGS)	318.2	408.4	414.2	436.8	445.8
Commercial Spaceflight Program	821.4	821.4	821.4	590.0	371.0
Commercial Cargo	0.0	0.0	0.0	0.0	0.0
Commercial Crew Program (CCP)	821.4	821.4	821.4	590.0	371.0
Exploration Research and Development (ERD)	364.2	340.8	347.8	390.7	398.7
Human Research Program (HRP)	165.1	164.6	169.5	175.4	180.0
Advanced Exploration Systems (AES)	199.0	176.2	178.3	215.3	218.7
Space Operations	**3,882.9**	**4,014.9**	**3,996.2**	**4,167.9**	**4,377.6**
International Space Station (ISS)	3,049.1	3,169.8	3,182.4	3,389.6	3,598.3
ISS Systems Operations and Maintenance	1,318.9				
ISS Research	226.4				
ISS Crew and Cargo Transportation	1,503.8				
Space Shuttle Program (SSP)	0.0	0.0	0.0	0.0	0.0
Space and Flight Support (SFS)	833.8	845.1	813.8	778.3	779.3
Space Communications and Navigation (SCaN)	554.5	562.7	521.4	506.5	507.5
Launch Services Program (LSP)	80.5	84.9	87.6	90.0	90.0
Rocket Propulsion Test Program (RPT)	47.8	47.3	47.7	48.0	48.0
Human Space Flight Operations (HSFO)	111.4	119.2	120.9	121.9	121.9
21st Century Space Launch Complex (21stCSLC)	39.6	31.0	36.2	11.8	11.8

Orion Accomplishments



Completed heat shield ready for transport to Textron in Boston, MA for Avcoat application

Inert Abort motor delivered to Operations and Checkout Building at KSC

Launch Abort System Ogive panel work at the Michoud Assembly Facility

Backshell panel drilling at the Operations and Checkout Building at KSC

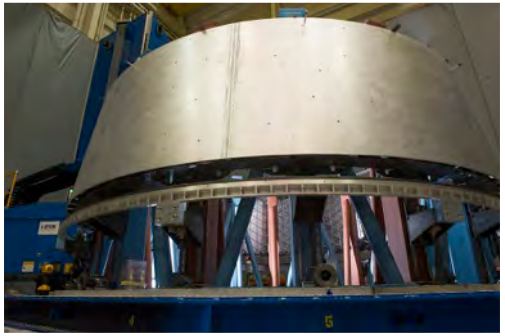
Service module assembly at the Operations and Checkout Building at KSC

Super Guppy carrying the Orion Heat Shield arriving at Hanscom Air Force Base in Boston, MA

SLS Accomplishments

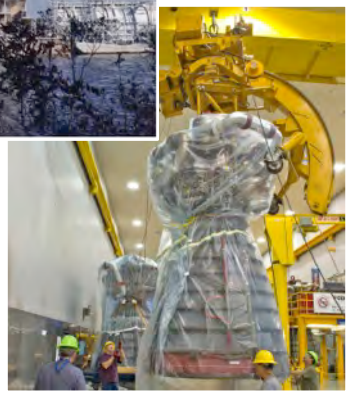
Systems Engineering & Integration SLS model wind tunnel testing at Langley Research Center
Nov 2012

J-2X upper stage engine hot-fire test at Stennis Space Center
Feb 2013



Multi-Purpose Crew Vehicle Stage Adapter (MSA) Flight Hardware at Marshall Space Flight Center
March 2013

Kennedy Space Center Pad 39B (artist's concept) with new crawler transporter and control room
Jan 2013



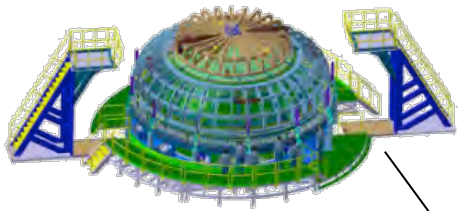
RS-25 Engines at Stennis Space Center Oct 2012, shown with future RS-25 Test Stand A1

F-1 engine gas generator – technology demonstration for an optional Advanced Booster concept – hot-fire test at Marshall Space Flight Center, Jan 2013

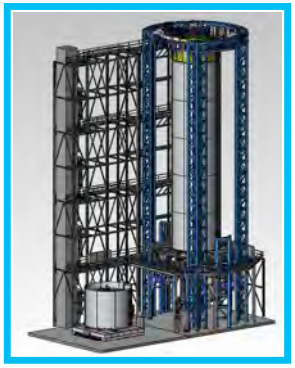
Qualification Motor 1 casting at ATK
Oct 2012

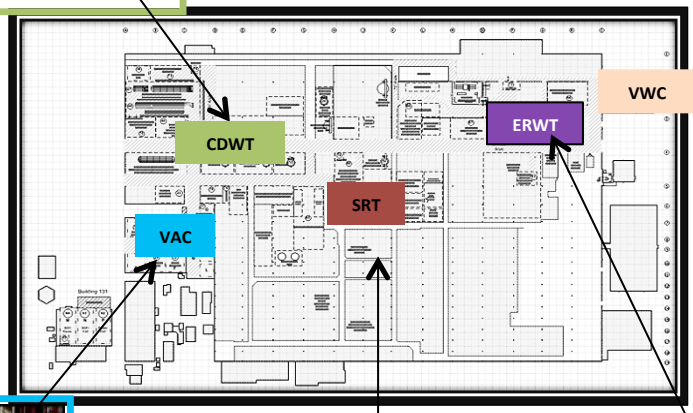
System Requirements Review/System Definition Review Completed

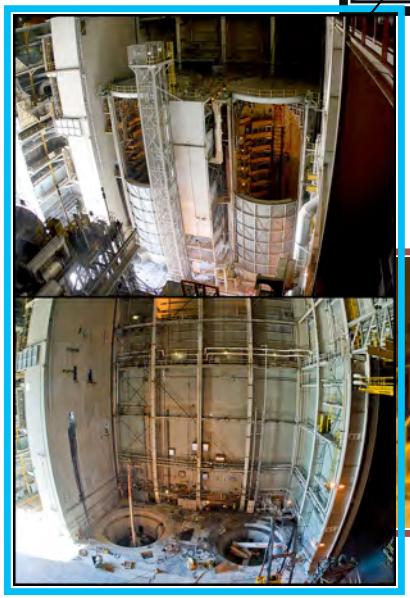
Stages Manufacturing, Assembly, & Production/ Operations Snapshot at MAF



Next Big Step	
Tooling Availability	May- Enhanced Robotic Weld Tool (ERWT) June- Vertical Weld Center (VWC)



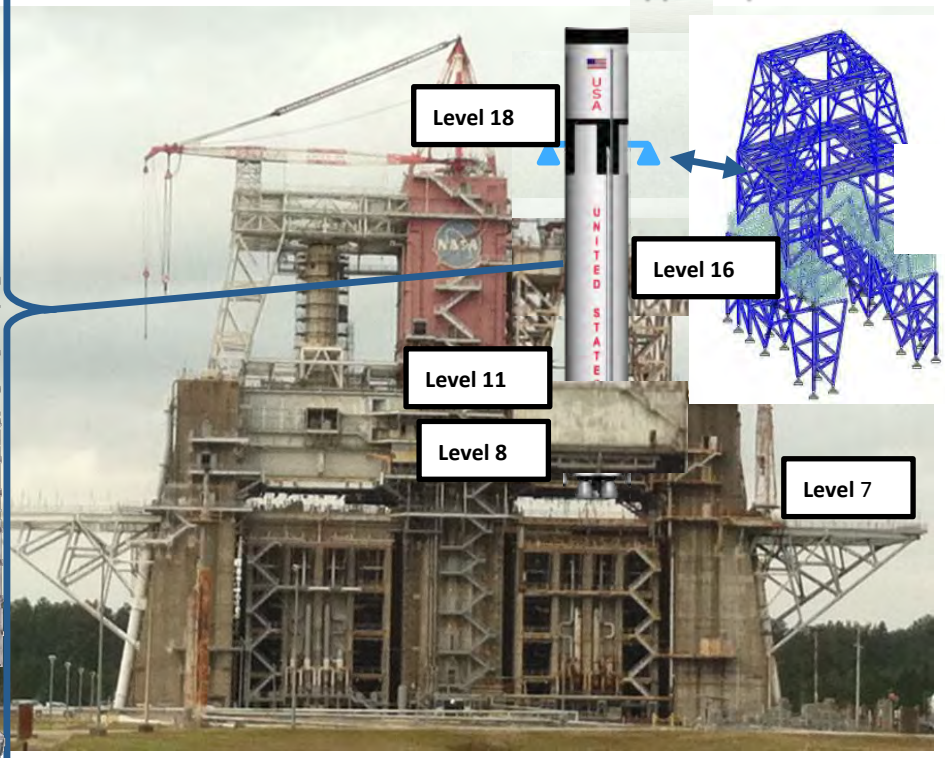




Stages "Green Run" Test Buildup at SSC B-2

Next Big Step	
Stage Testing	April 30% Design on Structural Build- Out & Electrical Restoration June Work Package 3 of 5 Awarded

Stage is 211" Tall



NASA Stennis Space Center, MS
Test Stand B-2 Stages Green Run

Level 7 Side after Demo & LOX Transfer Line

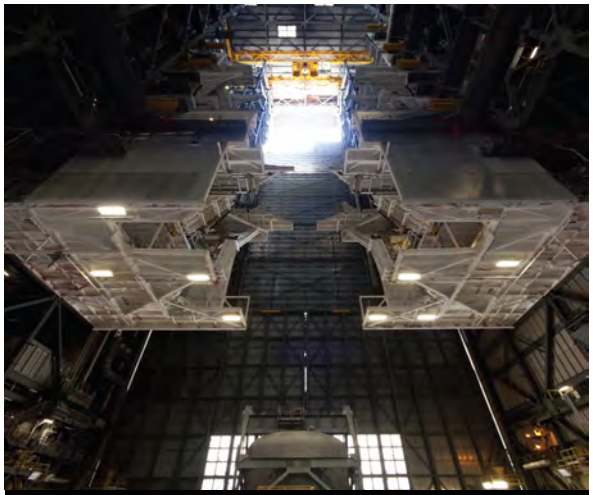
Above: Aspirator and Level 7 Demolition

Left: B-2 Flame Deflector Flow Testing

GSDO Accomplishments

Crawler-transporter Modifications

Crawlerway Modifications



VAB Modifications

Pad 39B Modifications including new hydraulic elevators

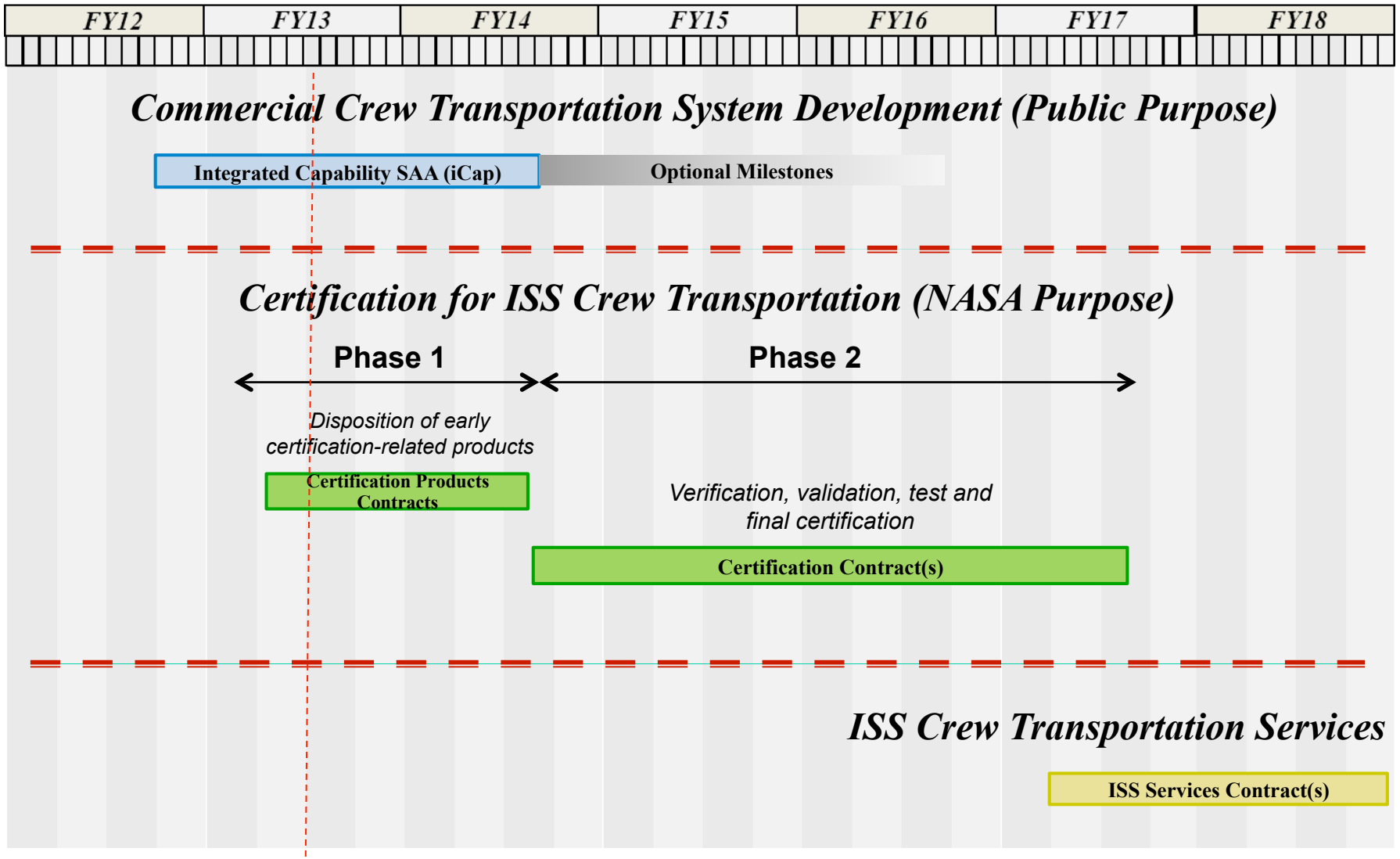
Testing of Crawler-Transporter 2

Pad 39B new interface connections

Antares A-ONE Rocket On the Pad

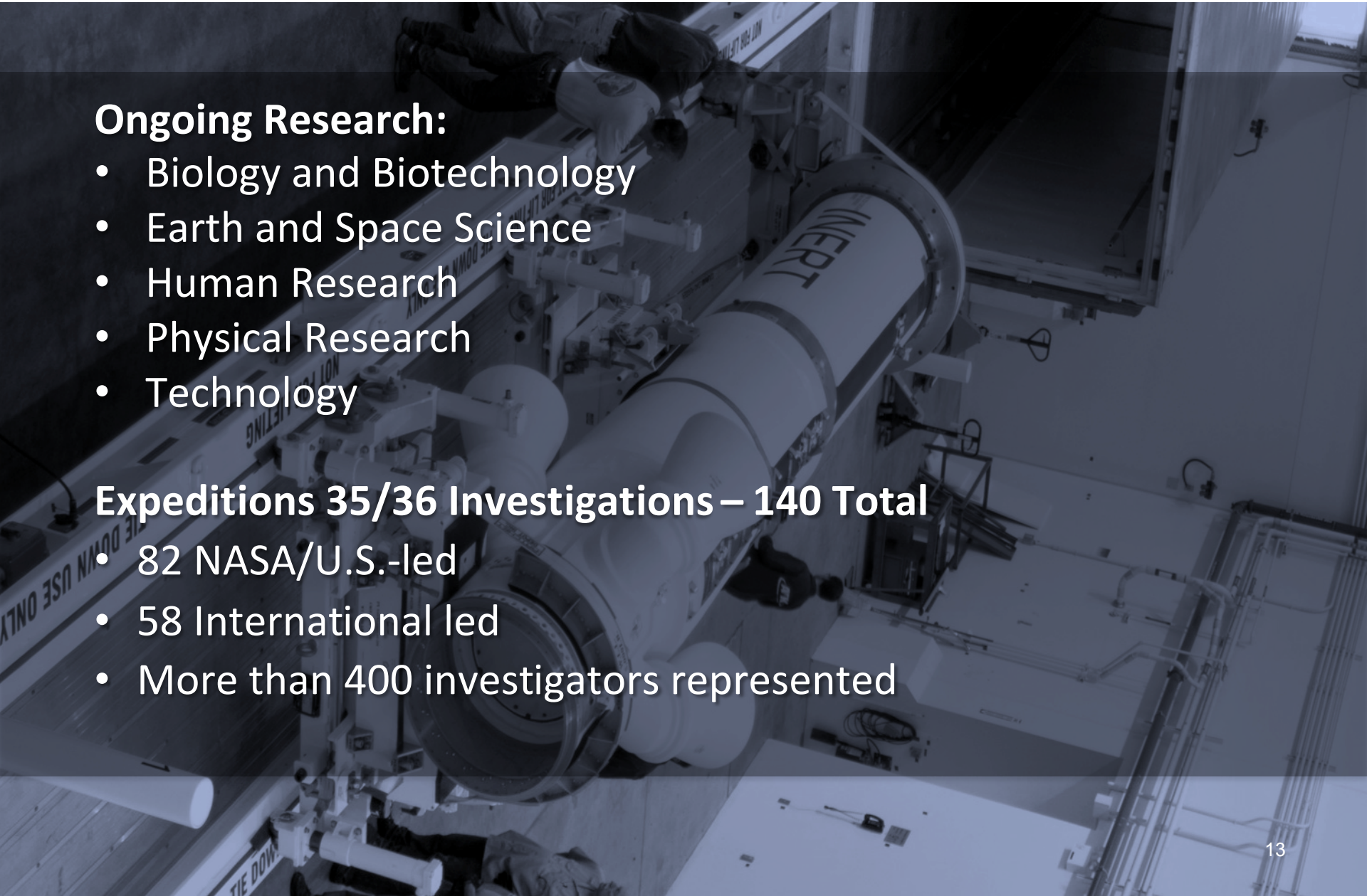
Cygnus Preparation for Fuel

CCP Roadmap


FY12
FY13
FY14
FY15
FY16
FY17
FY18
Commercial Crew Transportation System Development (Public Purpose)
Integrated Capability SAA (iCap)
Optional Milestones
Certification for ISS Crew Transportation (NASA Purpose)
Phase 1
Phase 2
Disposition of early certification-related products
Certification Products Contracts
Verification, validation, test and final certification
Certification Contract(s)
ISS Crew Transportation Services
ISS Services Contract(s)
Today

ISS – Orbiting Microgravity Laboratory with Continued Human Presence in Low Earth Orbit

ISS Research



Ongoing Research:

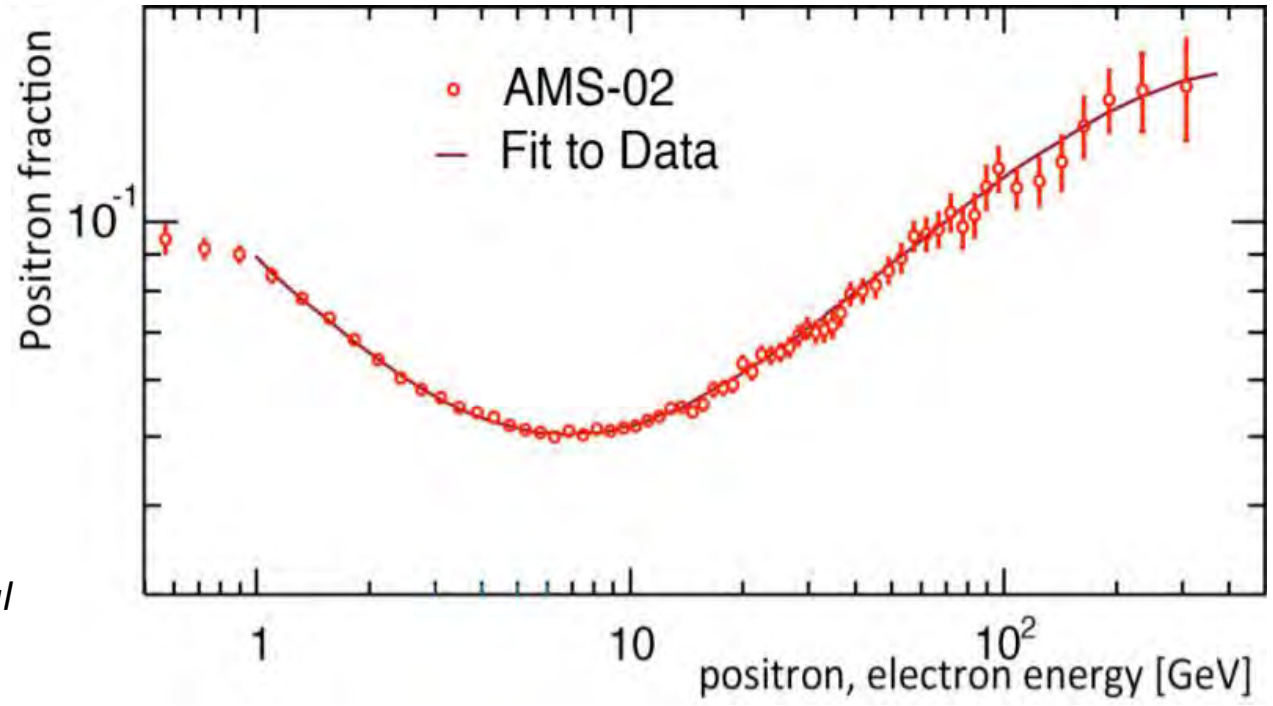
- Biology and Biotechnology
- Earth and Space Science
- Human Research
- Physical Research
- Technology

Expeditions 35/36 Investigations – 140 Total

- 82 NASA/U.S.-led
- 58 International led
- More than 400 investigators represented

International Space Station
First Results from Alpha Magnetic Spectrometer

"The exact shape of the spectrum...extended to higher energies, will ultimately determine whether this spectrum originates from the collision of dark matter particles or from pulsars in the galaxy. The high level of accuracy of this data shows that AMS will soon resolve this issue."



Credit: CERN Press Office release on paper in *Physical Review Letters*

Asteroid Strategy

- **NASA's asteroid strategy aligns relevant portions of NASA's science, space technology, and human exploration capabilities for a human mission, advanced technology development, efforts to protect the planet, and engages new industrial capability and partnerships**
- **Leverages existing NASA efforts**
  - Asteroid Identification and Characterization efforts for target selection
  - Solar Electric Propulsion for transport to and return of the target asteroid
  - Robotic servicing techniques for capture
  - SLS and MPCV missions for asteroid rendezvous
- **Benefits future exploration objectives for carrying humans further into space than ever before**
  - Deep space navigation and rendezvous to enable crewed operations in deep space
  - High power solar electric propulsion to enable efficient transportation to deep space destinations
  - In space robotics for capture/control of uncooperative objects

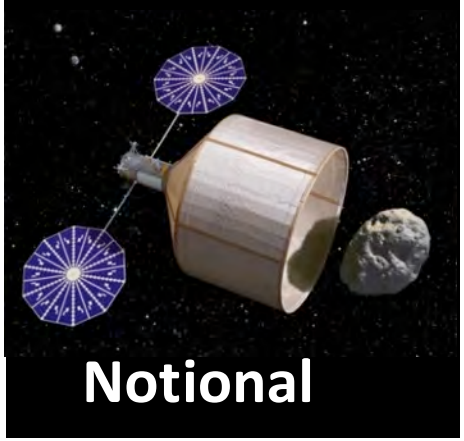
Asteroid Mission Would Consist of Three Main Segments

Identify

Asteroid Identification Segment:

Ground and space based NEA target detection, characterization and selection

Redirect



Asteroid Redirection Segment:

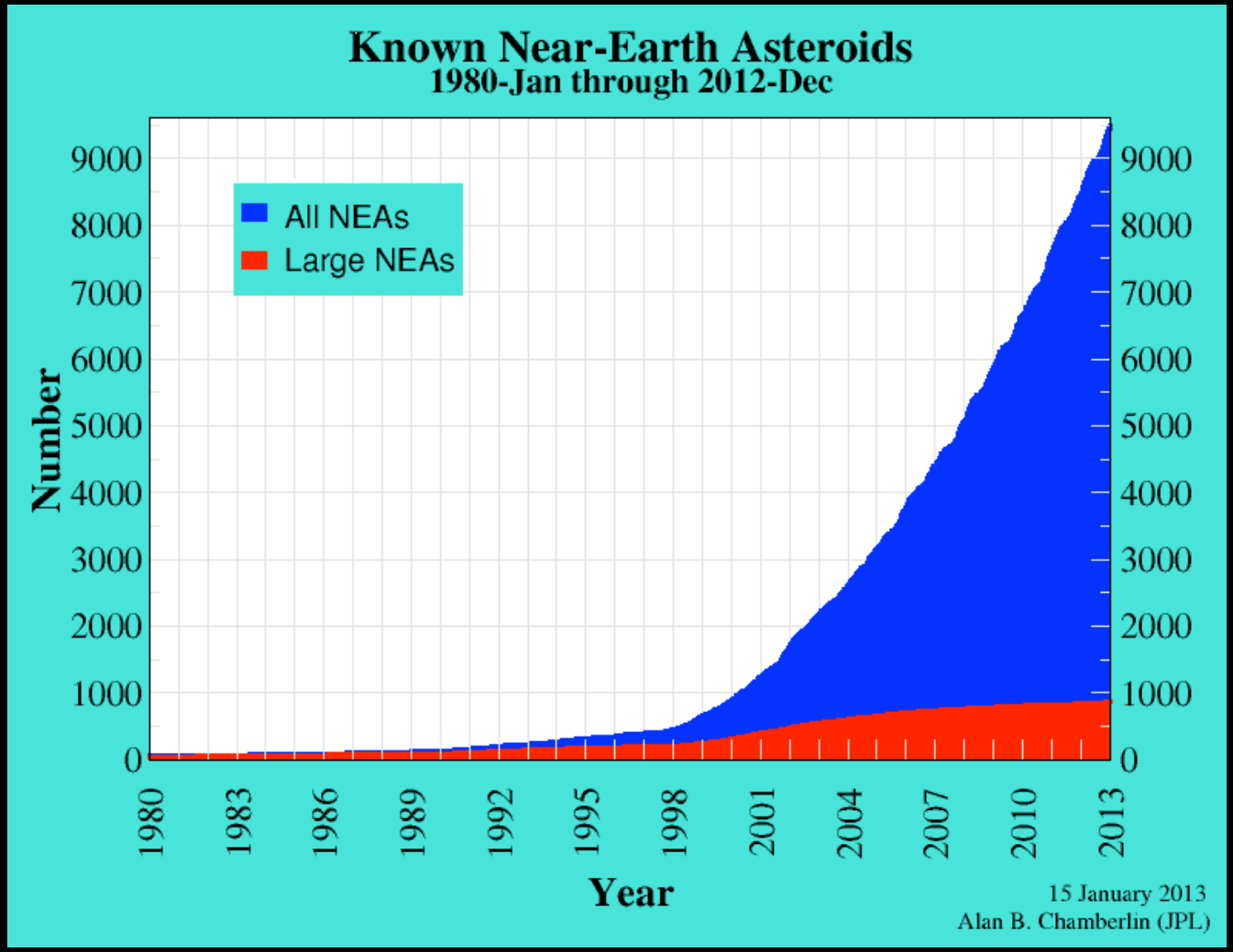
Solar electric propulsion (SEP) based asteroid capture and maneuver to trans-lunar space

Explore

Asteroid Crewed Exploration Segment:

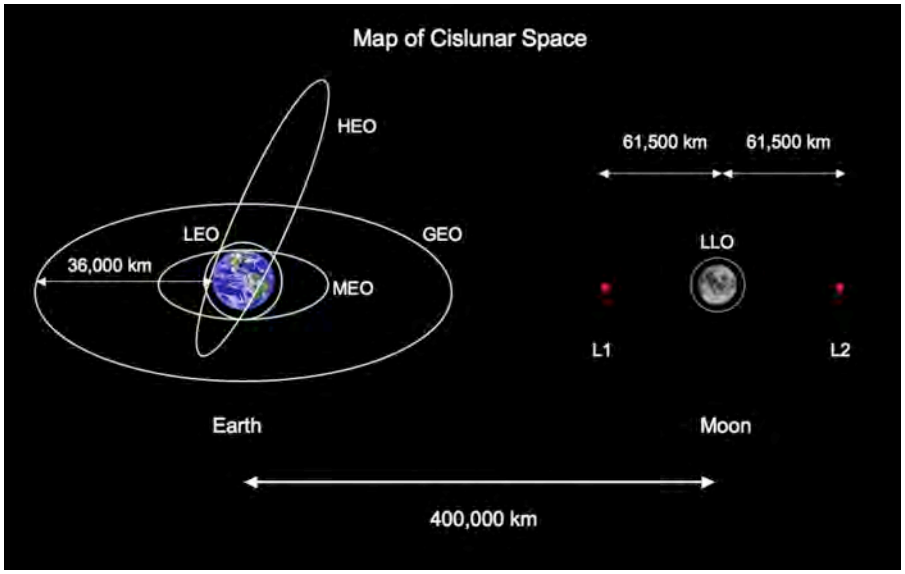
Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid

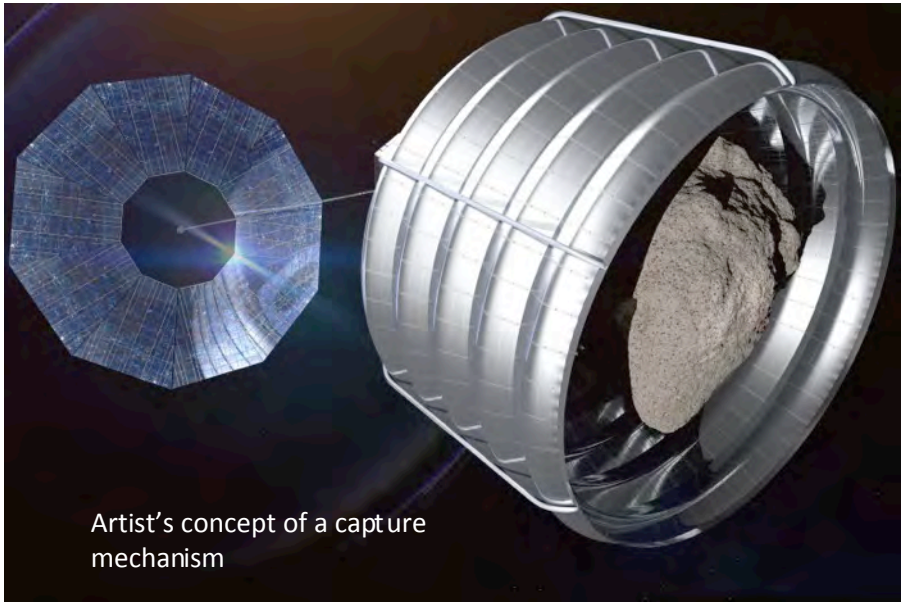
Near-Earth Asteroids (NEAs) at a Glance



Approximately 300 10-m-class asteroids have been found, about 13 of which meet orbital criteria.

Asteroid Capture & Retrieval Mission Concept



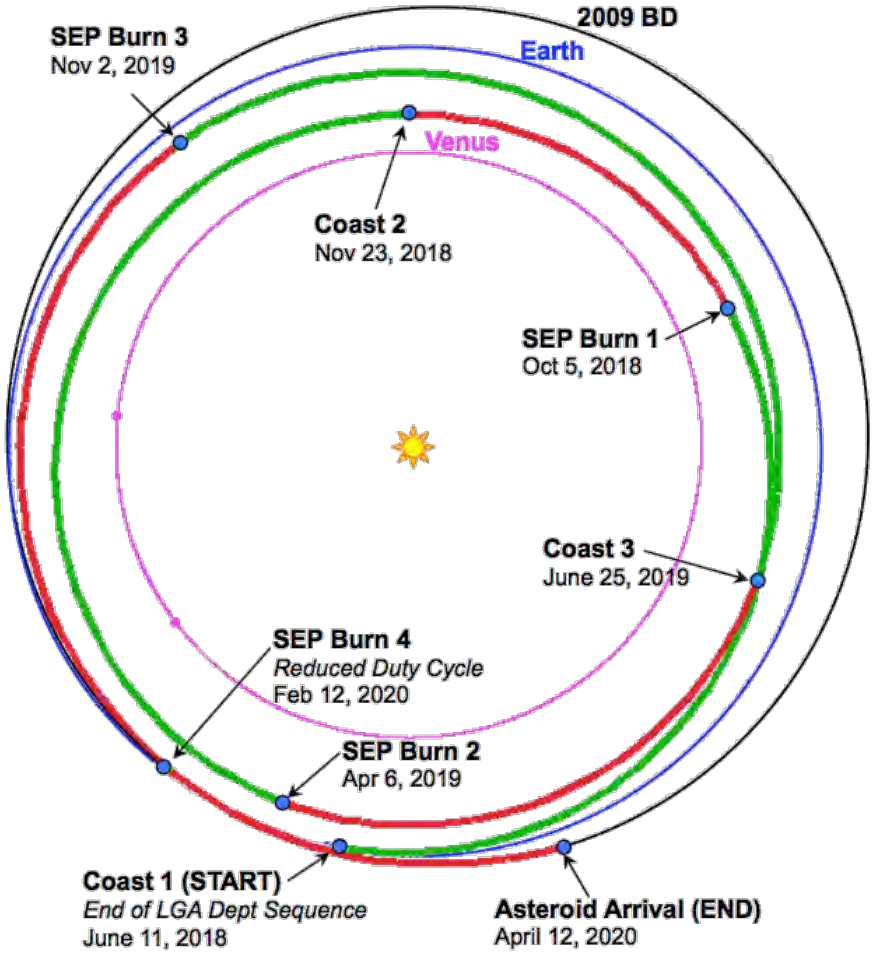

Artist's concept of a capture mechanism

- **Capture and redirect a 7-10 meter diameter, ~500 ton near-Earth asteroid (NEA) to a stable orbit in trans-lunar space**
- **Enable astronaut missions to the asteroid as early as 2021**
- **Parallel and forward-leaning development approach**

Interplanetary Trajectory

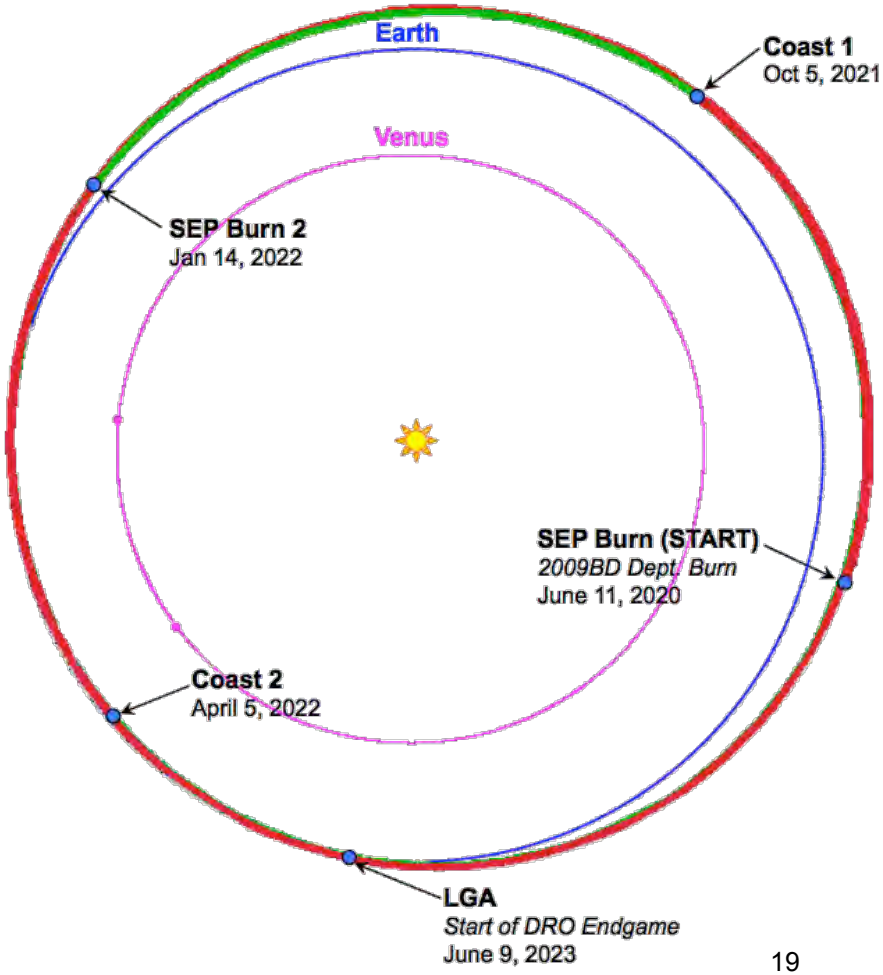
Trajectory to Asteroid

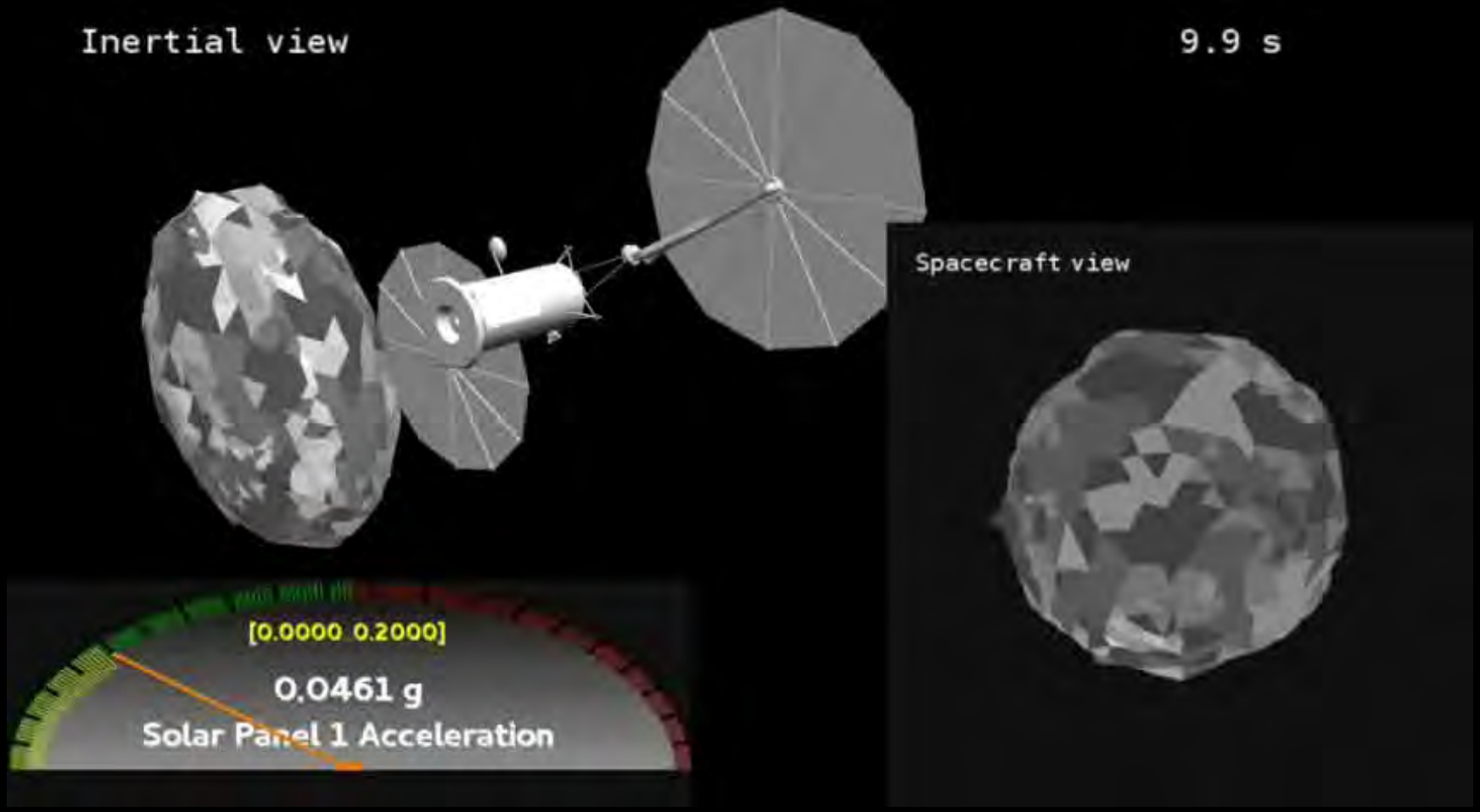
DV = 3868 m/s TOF = 671 days (1.84 yr)



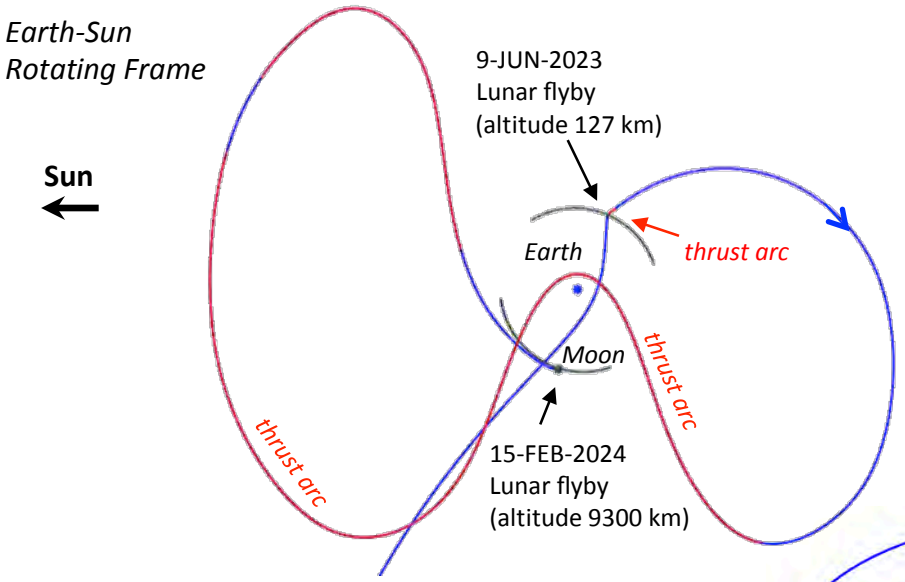
Asteroid Retrieval

DV = 152 m/s TOF = 1092 days (2.99 yr)




Inertial view
9.9 s
Spacecraft view
[0.0000 0.2000]
0.0461 g
Solar Panel 1 Acceleration

Earth-Moon System Trajectory

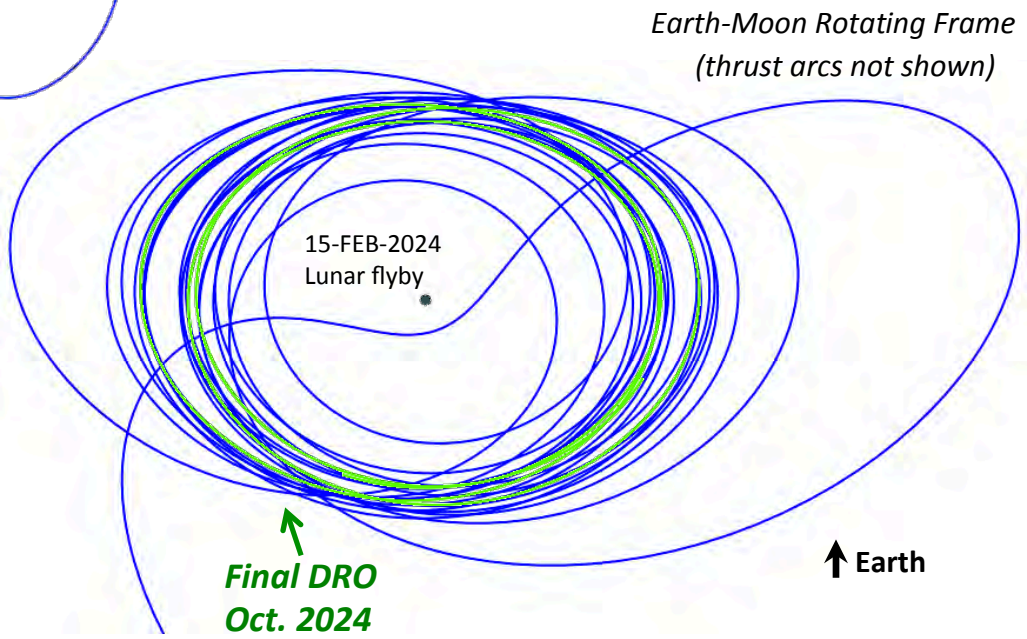


Trajectory to Storage Orbit

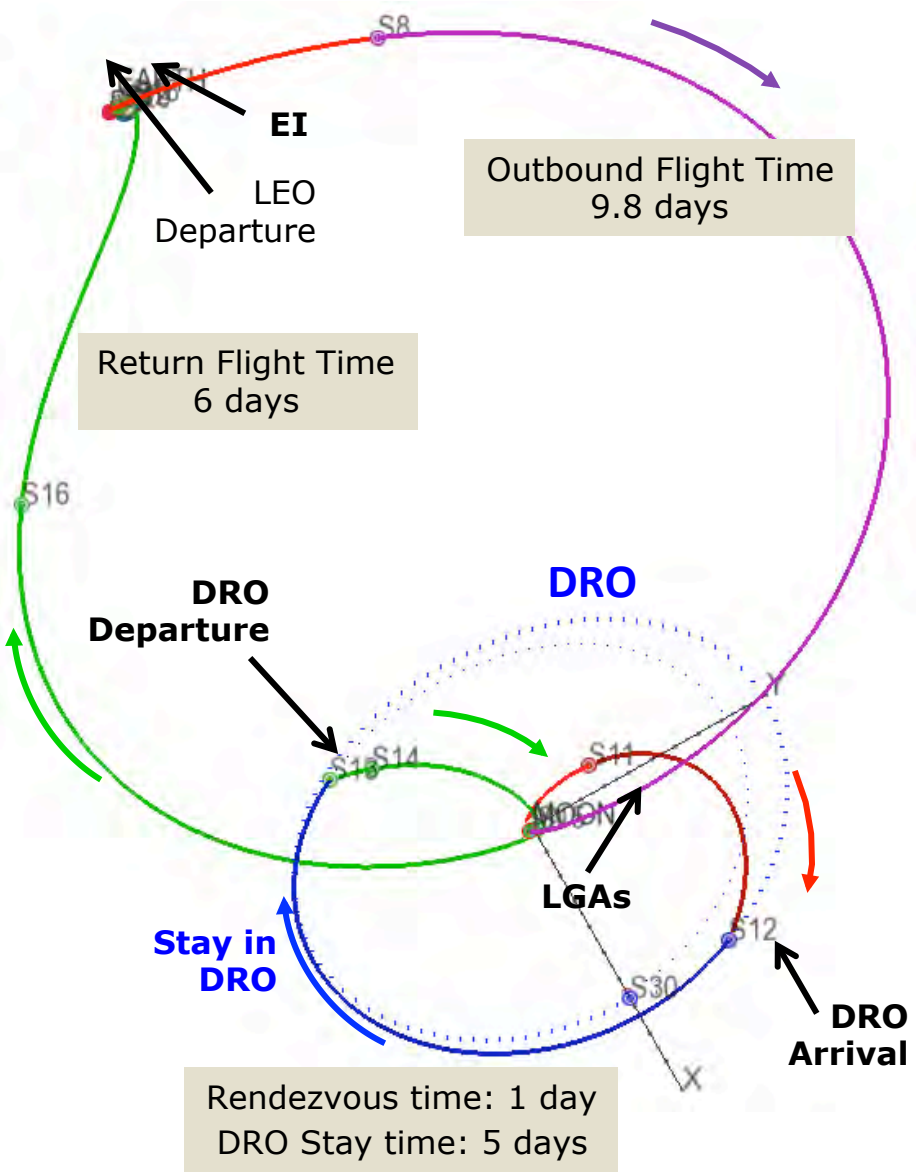
DV = 35 m/s
TOF = 251 days (0.7 yr)

Orbit Trim Maneuvers
(for long term stability)

DV = 25 m/s
TOF = 257 days (0.7 yr)



22 Day Nominal ARUM Mission Overview



- **MECO Epoch: 2024-Aug-13 22:28:05TDB**
- **Entry velocity: 10.99 km/s**

- **Total iCPS Δv: 2,779.23 m/s (Use all iCPS capacity)**
- **Total MPCV Δv: 1,200 m/s (~40m/s margin)**
- **Total Mission Duration: 22 days**

- **Outbound**
  - **FD01 – Launch/TLI**
  - **FD02-FD05 – Outbound Trans-Lunar Cruise**
  - **FD06 – Lunar Gravity Assist**
  - **FD07-FD09 – Lunar to DRO Cruise**
- **Joint Operations**
  - **FD10 – Rendezvous**
  - **FD11 – EVA #1**
  - **FD12 – Suit Refurbishment, EVA #2 Prep**
  - **FD13 – EVA #2**
  - **FD14 – Contingency/Departure Prep**
  - **FD15 – Departure**
- **Inbound**
  - **FD16 – DRO to Lunar Cruise**
  - **FD17 – Lunar Gravity Assist**
  - **FD18-FD21 – Inbound Trans-Lunar Cruise**
  - **FD22 – Earth Entry and Recovery**

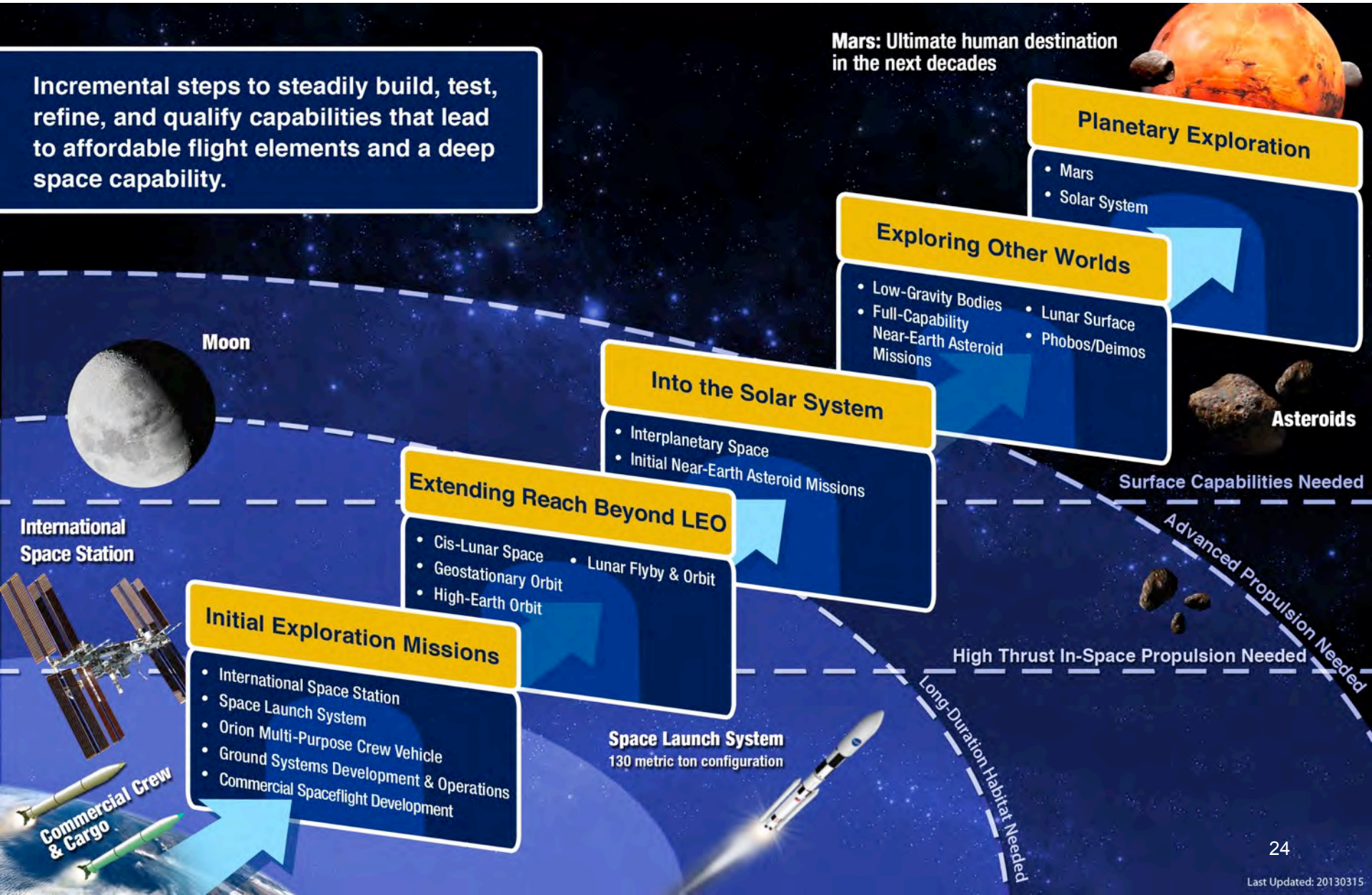
Mission Duration and timing of specific event will varying slightly based on epoch variation.

Asteroid Mission Capabilities Support Long-Term Mars Strategy

- **Demonstration of Core Capabilities for deep space missions:**
  - Block 1 SLS, MPCV, and ARV with 40kW Solar Electric Propulsion (SEP) system
  - EVA, proximity operations, AR&D, deep space navigation and communications
  - Human operations in beyond low earth orbit
  - Robotic sample acquisition, caching, storage operations, and crew transfer operations for future sample return missions (potential Lunar/ Mars Sample Return options)

- **Demonstrates ability to work and interact with a small planetary body:**
  - Systems for instrument placement, sample acquisition, material handing, and testing
  - Understanding of mechanical properties, environment, and mitigation of hazards

Capability Driven Framework



Last Updated: 20130315

Strategic Principles for Incremental Building of Capabilities

Six key strategic principles to provide a sustainable program:

1. Executable with current ***budget with modest increases***.
2. Application of ***high Technology Readiness Level*** (TRL) technologies for near term, while focusing research on technologies to address challenges of future missions
3. ***Near-term mission*** opportunities with a defined cadence of compelling missions providing for an incremental buildup of capabilities for more complex missions over time
4. Opportunities for ***US Commercial Business*** to further enhance the experience and business base learned from the ISS logistics and crew market
5. ***Multi-use*** Space Infrastructure
6. Significant ***International participation***, leveraging current International Space Station partnerships

Elements Required By Potential Destination

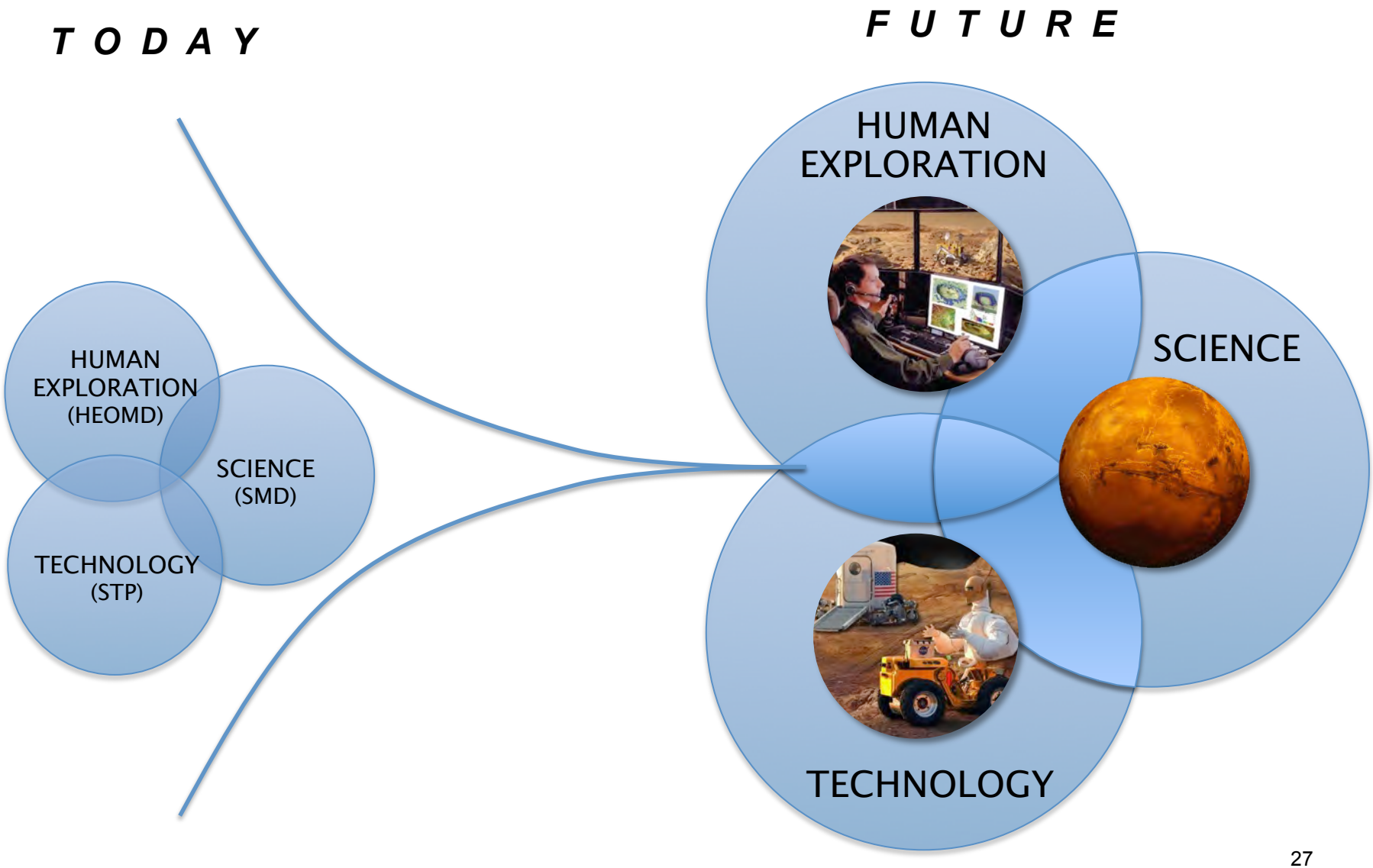
Phase	Capability	Potential Required Element	For Potential Destinations			
			L1/L2	Asteroid	Mars Orbit / Moons	Mars Surface
Getting There	BEO Access	**Space Launch System (SLS)**	X	X	X	X
	Crew	**Orion**	X	X	X	X
	High Thrust/Near Earth	**Cryo Propulsion Stage (CPS)**	X	X	Option	Option
	Low Thrust/Near Earth	**Solar Electric Propulsion (SEP)**	Option	Option	Option	Option
	High Thrust/Beyond LEO	**Nuclear Thermal Propulsion (NTP)**	Option	Option	Option	Option
	Low Thrust/Beyond LEO	**Nuclear Electric Propulsion (NEP)**	Option	Option	Option	Option
	Habitation	**Habitat**	Option	X	X	X
Working There	Descent	**EDL / Landers**				X
	Habitation	**Habitat**				X
	Micro-g Sortie and Surface Mobility	**Robotics and Mobility**		X	Option	X
	In Situ Resource Utilization	**In-Situ Resource Utilization (ISRU)**				X
	Surface Power	**Fission Surface Power System**				X
	EVA (nominal)	**EVA Suits**	X	X	X	X
Coming Home	Ascent	**Ascent Vehicle**				X
	Crew Return	**Orion**	X	X	X	X

Note:

X - Required Elements/Capabilities for these potential destinations

Option - Element/Capability may be needed or multiple options could exist to enable missions for that specific potential destination or could be for verification for future needs.

Human Mars Exploration Focuses Agency Technology and Capability Development



The Future of Human Space Exploration

Exploration Destinations and One-Way Transit Times

Human Spaceflight Capabilities

Robotics and Mobility | Deep Space Habitation | Advanced Spacesuits | Advanced Space Communications | Advanced In-Space Propulsion | In Situ Resource Utilization | Human-Robotic Systems

Last updated: 04/15/2013

Summary

- **Budget allows HEOMD to continue solid progress on existing activities**
  - SLS/Orion/Ground operations
  - ISS research, operations, and transportation
    - ISS proving value to research folks
  - Space Communications
  - Launch services
  - Commercial crew for low earth orbit
  - ISS research
  - Rocket propulsion and test
- **Budget is tight but workable**
- **Offers a strategy to link several planned activities into asteroid redirection**
- **Points the way an integrated approach to long term goal of Mars exploration**